

Risk and Protective Factors for Adult and Child Hunger Among Low-Income Housed and Homeless Female-Headed Families

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During the past 2 decades, numerous efforts have been made to define, operationalize, and measure the extent of hunger in the United States.^{1–12} Largely based on previously developed items,^{3,6,8,10–17} a multi item food insecurity and hunger measure was recently devised by the US government.^{18–23} This measure has been used since 1995,^{24,25} and the US government currently estimates that 10.1% of households—31 million Americans—are food insecure; of these, 3 million households experience hunger.²⁶

Several studies have examined economic and sociodemographic factors predisposing a household to food insecurity or hunger,^{3,6,8,27–32} but few studies describing other risk factors exist. Moreover, no study has examined the role of family member characteristics. Given previous research showing that food insecurity and hunger are a managed process,^{3,6–8,11–13,33} we explored family characteristics that could affect mothers' managerial capacity in homeless and housed female-headed families.

We defined *hunger* as resource-constrained food insufficiency. Independent variables included sociodemographic factors, maternal and family risk indicators (mental health and substance abuse, family violence, limited social support, residential instability, and homelessness), and protective factors (housing subsidies, emergency food program use, and participation in publicly funded programs). We hypothesized hunger to be positively associated with factors compromising a mother's managerial capacity or limiting her family's resources and negatively associated with protective factors. We sought to identify factors distinguishing not only hungry from nonhungry families but also (among the hungry) adult from child hunger to better understand why some poor

families experience adult or child hunger, whereas others do not.

METHODS

Participants

The Worcester Family Research Project was an unmatched case-control study designed to examine risk and protective factors for family homelessness and to provide information about low-income homeless and housed women and their children. A sample of 220 homeless women was recruited from Worcester's homeless shelters and welfare hotels (median duration of current homeless episode=8.67 weeks), and a comparison group of 216 never-homeless women was recruited from the Department of Public Welfare office to represent those at risk for homelessness. Because homelessness status (the grouping variable in the case-control design) was unrelated to our hunger measures (see next subsection), we based these analyses on the 354 respondents from both samples with complete hunger data who had at least 1 child living with them at the time of the interview. The hunger measure includes assessment of child hunger; it was therefore necessary to restrict analyses to families with

Objectives. We sought to identify factors associated with adult or child hunger.

Methods. Low-income housed and homeless mothers were interviewed about socioeconomic, psychosocial, health, and food sufficiency information. Multinomial logistic regression produced models predicting adult or child hunger.

Results. Predictors of adult hunger included mothers' childhood sexual molestation and current parenting difficulties, or "hassles." Risk factors for child hunger included mothers' childhood sexual molestation, housing subsidies, brief local residence, having more or older children, and substandard housing.

Conclusions. This study found that the odds of hunger, although affected by resource constraints in low-income female-headed families, were also worsened by mothers' poor physical and mental health. Eliminating hunger thus may require broader interventions than food programs. (*Am J Public Health*. 2004;94:109–115)

children present. Women excluded from the analyses differed slightly from the study sample: they were younger (average age of 25 vs 28 years), were less likely to be Hispanic (25% vs 39%), and had lower annual incomes (\$7875 vs \$9413).

Measures

Women were interviewed at the baseline of the Worcester Family Research Project and 1 and 2 years thereafter. The current analyses drew on data collected for the baseline wave. Highly trained female interviewers conducted 3 to 4 structured interviews with participants; each session lasted approximately 2 hours. Because of the high proportion of Hispanic participants, protocols were translated into Spanish by bilingual and bicultural translators and were conducted by bilingual interviewers when appropriate.

Hunger. We developed the hunger measure from a set of 7 dichotomous items, each of which asked respondents whether they or their children had experienced a particular aspect of hunger during the past year. Table 1 lists the 7 hunger items: 3 concern family or adult hunger, and the remaining 4 describe child hunger. All 7 derive from the Community Childhood Hunger Identification

TABLE 1—Questionnaire Items for Hunger Measure

- In the last 12 months,
1. Did you ever run out of money to buy food to make a meal?
 2. Did you ever eat less than you felt you should because there was not enough money for food?
 3. Did you ever cut the size of your meals or skip meals?
 4. Did your child(ren) ever eat less than you felt he/she(they) should because there was not enough money?
 5. Did you ever cut the size of your child(ren)'s meal?
 6. Did your child(ren) say he/she (they) was (were) hungry because there was not enough food in the house?
 7. Did your child(ren) ever go to bed hungry because there was not enough money to buy food?

Project^{8,10,12} measure, which correlates highly with earlier US Department of Agriculture and National Health and Nutrition Examination Survey hunger measures,¹⁵ has been validated by independent assessment,^{33,34} and has been used in several studies.^{34,35} These Community Childhood Hunger Identification Project items form a major component of the 18-item measure currently used by the US Department of Agriculture to estimate prevalence of food insecurity and hunger in the United States.^{18–23}

Reliability analysis indicated a high level of internal consistency among the items (Kuder-Richardson 20=0.84; average correlation=0.45), and factor analyses indicated that a single-factor solution best fit the data. Accordingly, we formed a simple additive scale with a theoretical range from 0 to 7, reflecting the number of hunger items out of 7 to which the respondent answered affirmatively.

To provide results more readily interpretable in the policy arena, we based the current analyses on a categorical measure derived from the continuous scale described earlier in this section. Trichotomizing into scores of 0, scores from 1 to 3, and scores of 4 or more provided a meaningful and useful method of grouping families based on the number of aspects of hunger experienced. Under this categorization, families in the first group (scores of 0) had no hunger, families in

the second group (scores of 1–3) had primarily adult hunger, and families in the third group (scores of 4 or higher) had both child and adult hunger. Because 4 of the 7 items concern child hunger, families in the third group (scores of 4 or higher) must have answered affirmatively to at least 1 child-related question and thus had child hunger present. Families in the second group (with hunger scores of 1–3) could theoretically have had child hunger present without adult hunger, but that pattern was in fact extremely rare in our sample, probably because parents preferentially allocated scarce food resources for their children's use. Nearly all of the respondents—341 (96%)—fit the pattern described here, and we are thus confident in conceptually identifying the groups as “no hunger,” “adult hunger,” and “child hunger,” acknowledging that families in the child hunger group have adult hunger present as well.^{14,15,18,19}

Risk and protective factors. Because of the paucity of public health literature on hunger in the United States, we adopted a broad analytic strategy that initially included a wide range of potential risk and protective factors. We started with an initial list of 94 such factors selected on conceptual and theoretical grounds, drawing on our past work and the existing literature.^{1,3,10,36–38} These factors, described in Table 2, are organized into 11 conceptual domains ranging from more distal, long-term potential hunger risks to more immediate precipitating factors. The grouping variable from the Worcester Family Research Project case-control design—homelessness status—was included in the Demographics domain.

Data Analysis

We used a modification of the method of purposeful selection of covariates described in

TABLE 2—Initial Risk and Protective Factors for Hunger

Domain	No. of Risk and Protective Factors	Description of Risk and Protective Factors	Standardized Measures
Demographics	8	Age, ethnicity, study homelessness status, marital status, acculturation	Short Acculturation Scale for Hispanics ³⁹
Distal factors	11	Respondent's parenting received as child, adverse child or adult events such as physical or sexual abuse, parental substance use, foster care placement	Parental Bonding Instrument ⁴⁰
Children	4	Number and age of respondent's children	
Housing	5	Housing problems, residential moves, tenancy, length of residency	
Health	10	Health status, health behaviors	Medical Outcome Study Short Form-36 (SF-36) ⁴¹
Mental health	6	Substance use, depression, posttraumatic stress disorder	Structured Clinical Interview for DSM-III-R, Non-Patient Edition (SCID-NP) ⁴²
Income	20	Poverty, work history, sources of income	
Psychological factors	10	Coping strategies, perceived parenting hassles ^a	Ways of Coping Questionnaire ⁴³ ; Parenting Daily Hassles ⁴⁴
Life events	1	Count of major life events in adulthood	Life Experiences Survey ⁴⁵
Services	7	Service utilization and perception of service needs	
Support	12	Social network size; social support provided by family, friends, and others	Personal Assessment of Social Support ⁴⁶ ; Inventory of Socially Supportive Behaviors ⁴⁷

^a“Hassles” are defined as “the irritating, frustrating, annoying, and distressing demands that to some degree characterize everyday transactions with the environment.”⁴⁴

Hosmer and Lemeshow⁴⁸ (see “Multivariate Model Predicting Hunger Status” subsection in this article) to select variables for a multivariate logistic regression model predicting membership in the hunger groups. The modification is that we first selected variables from within each of the 11 conceptual domains and then combined selected variables into a single model.

This selection process resulted in a set of 21 predictors that entered the final modeling analyses. The grouping variable from the Worcester Family Research Project case–control design—homelessness status—was not significantly related to hunger; therefore, we combined the homeless and housed samples for the analyses and kept the grouping variable in the multivariate models.

We tested the equality of the coefficients for the same variable in the 2 logit equations with a statistic defined as the difference between the 2 estimated coefficients divided by an estimate of the standard error of this difference. The estimated standard error took into account the correlation in the 2 estimated coefficients. The multivariate modeling approach allows for the possibility that adult hunger and child hunger may be qualitatively different states associated with different constellations of risk and protective factors.

RESULTS

Detailed information on the characteristics of the women in the Worcester Family Research Project sample ($N=436$) has been published elsewhere.^{36,37} The respondents in the current sample were young (average age=28 years) and in poor families, with 30% reporting incomes below 50% of the poverty line and 69% reporting incomes below 75% of the poverty line. Approximately two thirds (64%) of the women had never been married, and 44% had not completed high school. The sample was ethnically diverse, with equal numbers of White (39%) and Hispanic (39%) subjects and smaller numbers of women of African American (14%) and other (9%) descent. This ethnic breakdown reflected the composition of Worcester as a whole, which has a large Puerto Rican population.

TABLE 3—Risk and Protective Factors Selected via Variable Selection Procedure and Their Associations With Hunger Status (n = 354)

Domain	Risk and Protective Factors	No Hunger (0)	Adult Hunger (1–3)	Child Hunger (4–7)	P
Demographics	Age, mean	28.0	26.1	31.9	<.001
Distal factors	Count of childhood life events, mean	6.7	8.4	7.0	<.001
	Childhood sexual molestation, %	25.2	54.9	43.3	<.001
	Intimate partner violence, %	49.0	75.0	63.3	<.001
	Positive parenting as child, mean	2.3	2.2	2.1	<.001
	Foster care as child, %	12.0	15.9	6.7	.19
Children	Number of children, mean	1.8	1.8	2.5	<.001
	Presence of infant, %	29.4	20.3	6.6	.001
	Average age of children, mean	4.5	4.3	8.1	<.001
Housing	Number of housing problems, mean	0.8	1.1	1.8	<.001
	Living in Worcester < 1 y, %	19.4	23.3	31.2	.17
Health	General health (Medical Outcome Study Short Form-36), mean	71.0	67.3	59.8	.004
Mental health	Alcohol or drug abuse or dependence, %	28.8	47.0	41.0	.005
Income	Receiving housing subsidy, %	13.8	16.7	35.0	.001
	Receiving child support, %	17.5	11.4	26.2	.034
Psychological factors	Hassles ^a frequency, mean	37.5	42.5	40.1	<.001
	Coping: planning, mean	9.8	10.4	10.0	.37
	Coping: taking responsibility, mean	5.6	4.9	5.0	.077
Life events	Count of life events, mean	7.6	9.5	10.2	<.001
Services	Number of perceived needs, mean	1.6	1.6	2.0	.001
Support	Siblings helping with money, %	68.9	57.9	63.8	.17

^a"Hassles" are defined as "the irritating, frustrating, annoying, and distressing demands that to some degree characterize everyday transactions with the environment."⁴⁴

Hunger

Families varied substantially on the hunger measure, and all 3 hunger groups were well represented. The largest group (160 or 45%) had a score of 0 on the continuous measure (no hunger). A similarly large group (133 or 38%) had scores from 1 to 3 (adult hunger), whereas a smaller group (61 or 17%) had scores of 4 or greater (child hunger).

Associations of Potential Risk and Protective Factors With Hunger

Table 3 presents the 21 risk and protective factors obtained via the variable selection procedure and their bivariate associations with both adult and child hunger. Predictors from all (11) risk factor domains were selected via the procedure; the Distal Factors, Children, Housing, Psychological Factors, and Income domains each contributed more than 1 factor independently associated with

hunger status. The remaining 6 domains each contributed a single predictor.

Multivariate Model Predicting Hunger Status

Table 4 presents the final multivariate model of factors associated with hunger status. The top panel shows odds ratios comparing the no hunger with the adult hunger group, and the bottom portion presents corresponding odds ratios comparing the no hunger with the child hunger group.

The adult hunger and no hunger groups differed significantly on 6 of the 12 variables in the final model—2 risk factors and 4 protective factors. In a surprisingly strong finding, women who had experienced sexual molestation in childhood were more than 4 times more likely to have adult hunger in their families than were women who had not.

TABLE 4—Final Multinomial Logistic Regression Model of Hunger Status (n = 304)

Risk and Protective Factors	Odds Ratio (95% CI)	P
No Hunger vs Adult Hunger (0 vs 1–3)		
Age	0.93 (0.88, 0.99)	.016
Childhood sexual molestation	4.23 (2.28, 7.82)	<.001
No. of children	0.92 (0.67, 1.28)	.63
Average age of children	1.10 (0.98, 1.23)	.11
No. of housing problems	1.10 (0.86, 1.41)	.45
Housing subsidy (among housed)	1.50 (0.58, 3.84)	.40
Housing subsidy (among homeless)	0.78 (0.17, 3.62)	.75
Living in Worcester < 1 y	1.80 (0.87, 3.70)	.11
General health perception (SF-36) ^a	0.98 (0.86, 1.12)	.75
Receiving child support	0.39 (0.17, 0.89)	.025
Parenting hassles frequency ^b	1.60 (1.15, 2.23)	.005
Coping: take responsibility ^c	0.72 (0.54, 0.96)	.023
Siblings helping with money	0.52 (0.29, 0.94)	.031
No Hunger vs Child Hunger (0 vs ≥ 4)		
Age	0.95 (0.89, 1.02)	.16
Childhood sexual molestation	3.01 (1.30, 6.96)	.010
No. of children	1.56 (1.09, 2.25)	.016
Average age of children	1.20 (1.05, 1.37)	.007
No. of housing problems	1.57 (1.17, 2.13)	.003
Housing subsidy (among housed)	5.84 (1.99, 17.16)	.001
Housing subsidy (among homeless)	1.34 (0.22, 8.03)	.75
Living in Worcester < 1 y	2.73 (1.08, 6.90)	.033
General health perception (SF-36) ^a	0.77 (0.64, 0.92)	.004
Receiving child support	1.33 (0.51, 3.51)	.56
Parenting hassles frequency ^b	0.97 (0.64, 1.48)	.89
Coping: take responsibility ^c	0.72 (0.49, 1.04)	.080
Siblings helping with money	0.50 (0.23, 1.12)	.092

Note. CI = confidence interval.

^aOdds ratio for a 10-point increase in Medical Outcome Study Short Form-36 general health score.

^bOdds ratio for a 10-point increase in parenting hassles frequency score. "Hassles" are defined as "the irritating, frustrating, annoying, and distressing demands that to some degree characterize everyday transactions with the environment."

^cOdds ratio for a 3-point increase in taking responsibility coping score.

Nine of the 12 predictors differentiated families with child hunger from those with no hunger, 6 acting as risk factors and 3 serving as protective factors. Three risk factors were especially powerful: (1) the mother having been sexually molested as a child, (2) the family receiving a housing subsidy, and (3) the family living in Worcester for less than 1 year; each had an odds ratio greater than 2. Three factors emerged as protective against child hunger: mother's positive health, a coping style focusing on taking responsibility, and monetary assistance from siblings. Receipt of child support payments, although protective for adult hunger, did not protect against child hunger.

Because of the strength of the association between mothers' childhood sexual molestation and current hunger status, we used 4 sets of factors—physical health, mental health, work/income, and partner violence—to explore pathways by which sexual abuse in childhood might influence hunger status in adulthood. We speculated that being victimized as a child could lead a woman to have poorer physical or mental health, a more erratic work and earnings history, and an increased risk of partner violence and that these factors might, in turn, place her as an adult or her children at higher risk for current hunger. We used logistic regression models

with a dichotomous version of the hunger scale (no hunger vs any hunger) as the outcome and combinations of mothers' childhood sexual abuse and potential mediating variables as predictors. Two variables—having experienced partner violence as an adult and having a lifetime diagnosis of posttraumatic stress disorder—appeared to be mediators of the childhood sexual abuse–current hunger relationship. When these variables were placed with childhood sexual molestation in a model, they substantially reduced the effect of childhood sexual molestation on hunger status (odds for childhood sexual molestation declined from 3.13 to 2.14).

To determine whether different factors were associated with adult and child hunger, we tested the equality of each variable's parameter estimates in the 2 models. Three variables—mothers' childhood sexual molestation, a responsibility-focused coping style, and monetary help from siblings—behaved similarly in the 2 models. Six of the variables had estimated parameters that differed significantly between the 2 models, suggesting that different constellations of factors were predictive of adult and child hunger. Number of children in a household, number of housing problems, and a housed family's receipt of a housing subsidy were risks for child but not adult hunger. Because we detected a significant interaction between homelessness and receipt of a housing subsidy, we present odds ratios for the housing subsidy variable separately by homelessness status. Mothers' self-reported good health status was protective for child but not adult hunger. Two variables related to children—receiving child support payments and the parenting hassles measure—predicted adult but not child hunger.

DISCUSSION

By taking advantage of a comprehensive data set of low-income housed and homeless female-headed families, we identified risk and protective factors for adult and child hunger. Previous studies of a broader range of household incomes showed that factors connected to household poverty (race, gender, education, and employment status) also are related to hunger.^{8,12,23,27–31,49} In our sample, lack of variation in socioeconomic factors provided

little discriminatory power to explore these associations, but it allowed us to examine other moderating factors, including characteristics of the mother and environmental factors, such as housing problems. Although prior research identified protective economic factors,^{27–32,39} we are unaware of any studies observing the relative contribution of maternal and environmental factors associated with risk of hunger. Determining why some low-income families experience hunger but others do not is crucial to developing effective intervention strategies.

Most families in our sample experienced adult or child hunger. As hypothesized, adult hunger was related to factors compromising a mother's managerial, social, and financial resources (family violence, poor mental health, or brief local residence) or reflecting a strain on economic resources (more housing problems or more children to feed). Factors indicating greater managerial, social, or financial resources (money from siblings, child support, and mother's older age or better health status) were protective for adult hunger. Predictors of child hunger appeared to reflect greater demands on limited resources than did predictors of adult hunger.

We found that financial support from siblings and receipt of child support protected mothers from hunger. Many poor women cannot count on family members for such support,^{50–53} but for those who could in our study, the benefits were evident. On the contrary, families faced increased risk of hunger, particularly among children, if they had greater food requirements (more or older children) or more physical housing problems, likely reflecting extreme resource constraints (e.g., inadequate heat). Our finding of increased hunger risk among families new to the community may reflect the cost of transitioning, lack of employment, or lack of awareness of community supports and, therefore, a lack of ready access to food.

The study's failure to show a protective effect from Food Stamp Program participation is common to other studies.⁵³ In our sample, 95% of the households received food stamps, leaving little variability to distinguish a protective effect. Although benefit levels had greater variation, our model failed to find a protective effect here too. This is probably a

result of the Food Stamp Program's method of targeting benefits, in which they are inversely proportional to income and directly proportional to household size, meaning that families more at risk for hunger will receive higher benefits than those at less risk.

Families led by older women were protected from adult hunger. Older mothers may have benefited from more experience in managing limited resources, have been more resilient to the stress associated with poverty, have been better connected to public assistance programs, or have been better supported by personal relationships, all of which lower hunger risk.

Although we had *a priori* postulated that housing subsidies would be protective, our findings were otherwise. Perhaps this is because families receiving subsidies had been poor for a longer time than their counterparts. (Note that the relative dearth of public housing results in lengthy waiting lists.) In addition, perhaps families who had been homeless have increased priority status for or access to a subsidy. A housing subsidy, thereby, may have acted as a proxy for extreme or chronic poverty or a previous bout of homelessness.⁵⁴ We observed an interaction between receipt of housing subsidies and housing status, with the effect of housing subsidies existing only for those who were housed (not homeless). Further research is needed to understand and disentangle this relation.

Mothers' childhood sexual molestation was a powerful predictor of both adult and child hunger. Additional analyses conducted to examine this association found that women molested as children were more likely to be victims of adult partner violence and to have posttraumatic stress disorder. These conditions might have increased the risk of hunger. A large segment of the sample had experienced childhood sexual molestation or adult partner violence, both traumatic experiences that may lead to long-lasting physical health and psychological sequelae,^{55–60} such as depression, anxiety, emotional distress, and sleep disorders. The consequences of victimization, depending on their nature and severity, may impede a mother's capacity to carefully manage acquisition and distribution of sufficient food for her family in the context of severe resource constraints. Even for mothers

in good health, efficient use of limited resources to meet basic needs requires a deliberate, sustained process of self-organization, focus, and planning. For women enduring the emotional and physical effects of victimization, it is not difficult to imagine that these tasks can be overwhelming.

In the face of partner violence, mothers may continually fear for their own and their children's safety; protecting oneself and one's children can require all-encompassing planning, so that meeting family food needs may understandably receive less attention. To be effective, food assistance interventions for low-income families must take into account the effect of violence. Failure to identify a history of victimization may have serious hunger consequences for mothers and their children.

Four distinct, resource-related factors predicted child hunger: age and number of children, number of housing problems, and receipt of a housing subsidy. More and older children increased food requirements. If the food budget could not be expanded, food insufficiency ensued. This corroborates previous findings of hunger's tie to limited resources for basic needs (e.g., food and housing).^{8,10,12} Substandard housing conditions may have reflected not only extreme resource constraints but also an inability to negotiate a move. One factor protecting against child hunger was having a mother in better general health. Healthier mothers may have had more personal resources to cope with the stresses of, and more successfully manage, financial constraints. They also may have spent less time caring for themselves (e.g., trips to the doctor) or less money on care products (e.g., aspirin) and may have missed less work, all of which should have decreased their children's vulnerability to hunger.

We failed to identify a positive association between homelessness and hunger. One study found higher rates of hunger among homeless children,⁶¹ but it used a preliminary hunger measure and did not control for other factors commonly found among homeless children. Homelessness, like hunger, may result from diminished personal, financial, and social resources and, in and of itself, is not necessarily a risk factor.

When considering our findings, limitations in the study design should be borne in mind.

The sample design was developed to compare homeless with housed poor. Because hunger was a secondary outcome variable, this sample design could have influenced the results. Although we were interested in the relation between hunger and homelessness, the bivariate association between these 2 factors was not significant, so we chose to combine data from the 2 groups for the multivariate analysis of hunger predictors. The primary outcome measure depended on the mother's report, which may have been affected by her current distress. In addition, the 12-month time frame of the hunger measure could have resulted in overestimation of the hunger problem, whereas the shelter status of the homeless families could have resulted in its underestimation.

Sweeping conclusions cannot be drawn from an investigation of one mid-sized city; nevertheless, our findings highlight the need for preventive, family-oriented interventions that consider the broader needs of impoverished mothers and their children. Most previous research focused on the relation between sociodemography and food insecurity or hunger. This is understandable given that hunger is a poverty-based problem that will only be solved when families have enough income or food benefits to adequately feed themselves. Reducing hunger and its adverse health consequences requires a national strategy.

Our results showed that developing such a strategy requires a better understanding of the complicated interactions among individual, environmental, and financial factors affecting hunger in low-income families. Specifically, we discovered that food problems in low-income, female-headed families are affected not only by resource constraints but also by factors that may interfere with a mother's ability to effectively manage food acquisition and distribution tasks. For the first time, this study provides evidence that mothers' poor physical or mental health can itself predict hunger and, conversely, that their good health protects against hunger. Thus, eliminating hunger may require broader interventions than food programs, taking into account mothers' past and current traumatic life episodes and their potential effect on managing day-to-day needs, such as providing

sufficient food for family members in the context of severe resource constraints. At a minimum, families at risk can be screened in health and human service settings for hunger and provided with necessary aid, including linkage with food assistance benefits when eligible, referral to communities' emergency food and housing resources, and development of strategies for improving mothers' health and well-being. ■

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Contributors

C. Wehler collaborated in the supervision of the study's conceptualization and analysis and led the writing of the article. L. F. Weinreb conceived the study, supervised its implementation and analysis, and helped write the article. N. Huntington, R. Scott, and D. Hosmer assisted with analysis and writing. K. Fletcher, R. Goldberg, and C. Gundersen helped to conceptualize ideas, interpret findings, and review drafts.

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Human Participant Protection

The study received approval from the University of Massachusetts Medical Center institutional review board, and informed consent was obtained from study participants.

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